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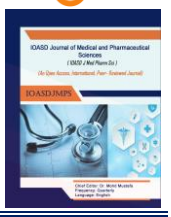

Comparative Study on the Microbiological and Physico-Chemical Properties of Spring Water and Tap Water

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ABSTRACT

Comparative study on the microbiological and physico-chemical properties of spring water and tap water was carried out, samples were serially diluted and cultured on Nutrient agar, macconkey agar, Mannitol salt agar and SDA using the pour plate method of inoculation. the total heterotrophic bacteria count ranged from 6.0×10^3 to 3.0×10^4, the total coliform count ranged from 3.2×10^3 to 8.0×10^4 no growth was recorded for staphylococcal count and Total Fungal Count for the samples ranged from 3.0×10^3 to 6.0×10^4. It was found that the isolates belonged to Klebsiella spp, Bacillus spp, *E. coli* and Pseudomonas spp**.** Bacillus spp had a percentage distribution of 19, while Klebsiella spp had a percentage occurrence of 24, also Pseudomonas spp had a percentage distribution of 24 and *E. coli* had a percentage distribution of 33 Physico-chemical analysis showed that the physic-chemical parameters where within the range of WHO standard. This study revealed that in all the water samples analyzeed some had bacteria loads though some did not exhibit the presence of bacteria and the bacteria isolated are of public health importance as they have being linked to disease outbreak and can cause severe health challenges to mankind if there is continued intake Residents who use sampled water as their source of drinking water should apply some purification or water treatment techniques like boiling before drinking so that the pathogenic bacteria isolated can be killed before consumption

Keywords: microbiological, physico-chemical properties, spring water, tap water.

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INTRODUCTION

The risk of spreading waterborne diseases and the potential for numerous infectious outbreaks are increased when bacteria from contaminated household water sources are the cause of waterborne illnesses. According to data from the World Health Organization (WHO) on the burden of disease, poor water quality, poor sanitation, and poor hygiene are responsible for roughly 3.2% of deaths (1.8 million) and 4.2% of years of life adjusted for disability (61.9 million) globally [1].

Numerous intestinal illnesses, including cholera, typhoid fever, infectious hepatitis, amoebic dysentery, and bacillary dysentery, can be spread through water [2]. The primary modes of transmission are by ingestion, contact, or transfer, all of which are readily avoided by strictly enforcing excellent hygiene and sanitation practices, putting into practice simple techniques that will lessen or completely eradicate the presence of dangerous bacteria, and filtering the contaminated water to supply clean water for human use and consumption that has been tainted [3]. Water, sanitation, and hygiene, according to WHO, help avoid at least 9.1% of the world's disease burden and 6.3% of all fatalities [4].

Currently, fecal and total coliform bacteria are monitored for in order to ensure the microbiological safety of water sources. The fecal coliform group is a subgroup of total coliform, which is made up of fewer varieties of bacteria than the total coliform group, which is a big collection of diverse types of bacteria. [5] Escherichia coli is thought to be a significant indicator of fecal contamination of water, and the bulk of water quality analyses performed globally focus primarily on determining the presence of E. coli in water [6]. Urinary tract infections and other intestinal and extra-intestinal disorders are frequently caused by different serotypes of Escherichia coli, and it is widely held that this species is the only one that can accurately predict the presence of fecal pollution in water [7].

Because E. coli O157 can cause outbreaks of waterborne diseases, there is a strong correlation

between water quality and safety [8]. Chlorinating residential water tanks and pipes at least twice a year could help solve this issue by enhancing water quality and safety and lowering the likelihood that E. coli will survive and spread through water consumption [9]. One essential element of life is water, which comes from lakes, wells, streams, ponds, rain, and oceans, among other places. Despite the abundance of water sources on Earth, the amount of acceptable useable water is greatly reduced when the term "portability" is added to it. Therefore, water can be categorized as unpolluted or polluted depending on how hygienic it is for home use [10].

MATERIALS AND METHODS

Study Areas

Ngwu Spring Natural Water served as the research's subject area. Known by another name, Iyi Umugara, this natural spring in the state's Nkwere local government region offers pure, glittering, crystal-like water. Tap water from the area should also be used.

Materials

The materials used, include: petri dishes, sterile glass slides, bent glass rod, forceps, pipette, Conical flasks, beakers, inoculating needles and loops, test tubes, test tube rack, Agar media, Autoclave, Hot air oven, Bijou bottles, Nose mask, hand gloves, test tubes covers, Cotton swab, Aluminium foil, cover slips, Durham tubes spatula and Bunsen burner.

Reagents

Distilled water, Methyl red, Kovac Reagent, Lugol's iodine, ethanol, Oxidase reagent, Glucose phosphate peptone water, Crystal violet, Immersion oil, Normal saline, Hydrogen peroxide, Sodium hydroxide solution, Peptone water and Safranine.

Source of Sample Collection

Four different tap water samples were used while 3 different sampling points was used from the spring water.

Collection of Samples

The samples for Bacterial analysis was collected aseptically in sterile tubes and samples for physicochemical analysis was collected in clean bottles with screw caps and sent for analysis at Imo state university microbiology laboratory.

Media Preparations

The solid components of the media were dissolved in a conical flask according to the manufacturer's instructions, The flask were closed with cotton plug and covered with Aluminium foil, placed into an autoclave and sterilized at 121^0C for 15mins. Following sterilization, the medium were cooled to 45^0C, the cotton plug was taken out, and the flask's mouth was burned over a Bunsen burner to guarantee sterility. The medium was then transferred into sterile, empty petri dishes, with 15–20 ml of medium in each. The petri dishes were kept horizontally until the medium are completely solidified, then they were turned upside down and stacked for storage.

The plates were labelled according to the medium and also a sterility test were performed on them by incubating some plates at 370C for 24hrs and after which they were examined [11].

Sterilization

All glass wares to be used were sterilized after washing with detergent using hot air oven, the Nutrient agar, MacConkey and Simmon's citrate agar and Peptone water were sterilized by Autoclaving at 121^0 C, 15Psi. Wire loops were sterilized by flaming to red hot using Bunsen burner and all laboratory benches were cleaned before and after work with 75% alcohol. Bunsen burner were lit during the course of the experiments to keep the environment sterile [12].

Microbiological Analysis of Samples

1ml each of the sample were added to 9ml of distilled water and were used for serial dilution, which were carried out as follows-

5 Test tubes containing 9ml distilled water each were labelled A - E.

Using the sterile distilled water and separate pipettes, serial dilution of the sample each were prepared. 1ml of the homogenized suspension were introduced into 9ml sterile distilled water and homogenised = 10^{-1} dilution. 1ml of A were added to 9ml sterile distilled water of B and homogenised=10^{-2} dilution. 1ml of B were added to 9ml sterile distilled water of C and homogenised = 10^{-3} dilution. 1ml of C were added to 9ml sterile distilled water of D and homogenised = 10^{-4} dilution [13].

After the serial dilution, pour plate method of inoculation was done using 0.1ml of the serially diluted sample each were inoculated into a sterile petri dish and 20ml 0f freshly prepared molten Nutrient agar (For Total Heterotrophic Plate Count), The petri dish containing the inoculums was filled with MacConkey agar (for the Coliform count) and SDA. The mixtures were then mixed thoroughly on a table, and the media were then incubated for 24 hours at 370C for the bacterial isolation media.

The plates were examined and the colonies enumerated following the incubation period. To obtain a pure culture, the distinct colonies were then subcultured into a newly prepared Nutrient agar plate. After a 24-hour incubation period, the sub-cultured plates were checked for pure culture. Gram staining, motility testing, and biochemical tests such as Oxidase, Citrate Utilization, Indole, Methyl-red, Vogesproskaeur, Coagulase, Sugar Fermentation, and Catalase were

performed on pure culture growths to characterize the organisms. A bijou was used to create a stock culture: this stock culture was used in storing the organisms for further characterization.

Identification of Isolates

The bacterial isolates were identified using colonial, cellular characteristics, Gram Staining, Motility test and biochemical properties. Biochemical test carried out include; Urease test, Citrate Utilization test, Indole test, Methyl-Red test, vogesproskeaur test, Coagulase test, Sugar test and Catalase test.

Colonial and Cellular Characteristics

Colonial and cellular characteristics were used in the identification of microbial isolates and they include; Colony's shape, colour, consistency, surface appearances and size

- Size of the colony (small,medium,large)
- Shape or form of the colony (punctiform, circular, irregular, filamentious, rhizoid, spindle)
- Elevation of the colony (flat, convex, pulvinate, umbonate, crateriform)
- Margin of the colony (entire, undulate, lobate, filamentous)
- Pigmentation of the colony (diffusible water soluble or water-insoluble pigments)
- Surface of the colony (smooth, glistening, rough, dull, wrinkled)
- Density of colony (transparent-clear, opaque, translucent-almost clear, but distorted vision-like looking through frosted glass, iridescent-changes colour in reflected light) [11].

Gram's Staining

Gram staining method described by [12] was adopted. With the aid of a sterile inoculating wire loop; smears of the isolates were made on clean, grease-free microscope glass slides, air-dried and heat-fixed by passing the slides 2-3 times over a Bunsen burner flame. Afterwards, each smear was covered with a Crystal violet (primary stain) for 30 seconds, after which it were quickly werehed off with clean water. The smear was flooded with lugol's iodine (Mordant) for 60 seconds. After, they were decolorized with 75% alcohol for 30seconds, which were washed off quickly with clean water and counter stained with safranin for 30 seconds. The safranin stain was washed off quickly with clean water. Back of the slides were then wiped and placed in a draining rack to air-dry. The smear was then examined microscopically using the oil immersion objective (X100). Gram positive cells showed purple while gram negative cells showed red colour [12].

Motility Test

The method described by [12] was adopted. It is used to differentiate between motile and non-motile organisms due to the presence of locomotory structures like flagella. This test was carried out using the stab method. Test tubes of semi-solid motility medium were inoculated by stabbing a sterile straight wire loop charged with inoculums from the isolated pure culture vertically into the media and it were incubated at 370C for 24hours. Non-motile bacteria produced growths that were un-diffused from the line of stab while motile bacteria produced diffused growth away from the line of stab into the medium and rendered it opaque

Biochemical Tests

Some of the biochemical tests to be used in identification bacteria shall include-

Catalase Test

The method as described by [14] was adopted. This is a test used to differentiate catalase producing bacteria like Staphylococci from non-catalase producing bacteria such as Streptococci. The catalase produced acts as a catalyst in the breakdown of hydrogen peroxide to oxygen and water. A drop of 3% hydrogen peroxide were placed on each end of a microscope slide, with the aid of a sterile wire loop, colonies of the test organisms were transferred on to one end of the microscope slide, and the other end were not inoculated but served as a control. The presence of gas bubbles indicates a positive catalase test, while absence of bubbles indicates a negative catalase test.

Citrate Utilization Test

This test is used to determine who belongs to the Enterobacteriaceae family. The test is carried out to-demonstrate the use of citrate as a sole source of carbon by alkalinisation of the medium and ammonia as the only source of nitrogen by the bacteria. The Method as described by [11] was adopted. The test were carried out by inoculating sterilized Simmon's citrate agar with the test organisms using a sterile wire loop and incubating at 370C for 48 hours and observing for changes in colour. Positive result shows a change of the medium colour from green colour to royal blue colour, indicating the presence of citrate utilizing bacteria.

Coagulase Test

The test demonstrates the ability of bacteria to produce coagulase as a defense mechanism, by clotting the area of plasma around it by converting fibrinogen to fibrin, thereby enabling them resist phagocytosis. It is used for the identification of Staphylococcus aureus. The method as described by [12] was adopted. The microscope slide was placed with a drop of distilled water.

A colony of test organism was emulsified in each of the drops of distilled water that were placed on the ends of the microscopic slide, to make thick suspensions. A 100cfu/l of plasma were added to one of the suspension and mixed gently. No plasma was added to the same suspension serving as control. Clumping of the mixture within 10 seconds will indicate positive

coagulase test, while absence of clumps within 10seconds indicates a negative result.

Indole Test

It was decided to use the [12] approach. When identifying enterobacteria, it is crucial to test for the formation of indole. The tryptophan-containing culture medium is used to cultivate the test organism. Kovac's reagent, which contains 4-p-dimethylaminobenzaldehyde, is used to detect the formation of indole. When indole and this compound react, a red substance is produced. The test organisms were inoculated in a bijou bottle with 3 ml of sterile tryptone water, and they were then incubated for 48 hours at 370C. Following this time, 0.5 ml of Kovac's reagent was added, and the tubes were gently shaken. A positive indole test is indicated when a red surface layer appears within 10 minutes.

Oxidase Test

The procedure outlined in [12] was used. Pseudomonas, Neisseria, Vibrio, Brucella, and Pasturella species—all of which generate the enzyme cytochrome oxidase—can all be identified with the help of this test. A small amount of oxidase reagent (tetra-ethyl-p-phenylendeaminedihydrochloride) was soaked onto a sheet of filter paper. Using a sterile glass rod, a colony of the test organism was selected and spread out across the filter paper. The oxidation of the phenylendeamine causes a blue-purple color to appear within a few seconds if the organism is an oxidase producer; on the other hand, the lack of a blue-purple color denotes a poor outcome.

METHYL RED/ VOGES-PROSKAUER {MR/VP}

This test is used to determine which fermentation pathway is used to utilise glucose [11] It is used to differentiate bacteria that are capable of fermenting glucose with the production of enough acid to lower the pH of the medium to 4-4.5 and that ferment glucose without much acid production. Methyl red contains glucose and peptone. The method as described by [11] was adopted. The bacteria isolates were inoculated into 2mls of glucose phosphate (peptone water) and were incubated at 37^0C for 48hours. After the period of incubation, 4 drops of methyl red indicator were added to the tube. The solution were homogenised and observed immediately for colour change. The appearance of a red colour indicates a positive result while the appearance of a yellow colour indicates a negative result. For Vogesproskauer test, the method described by [11] was adopted. The bacteria isolates were added to 2ml of glucose phosphate (peptone water) and it were incubated at 37^0C for 48hrs, after incubation, 40% KOH and 3ml of 5% alcoholic alpha-naphthol were added, the appearance of a pink colour after 2-5 minutes indicates a positive result.

Sugar Fermentation Test

This test was used to determine whether an organism could ferment sugar. Triple Sugar Iron (TSI) is the name of the agar used in this test. This test determines if the organism is basic or acidic based on its ability to create hydrogen sulfide, gas, and the fermentation of glucose, maltose, and fructose. The agar was sterilized for 15 minutes at 1210C. An angled test tube was used to inoculate the test organism. The use of several sugars is indicated by a color shift from purple to yellow. The presence of H2S is shown by a black duct at the slanted area. Additionally, the presence of gases is indicated by a gaseous bubble at the test tube's bottom or slant, and the displacement in the Durham's tube shows gas production [14].

Identification of Fungi Isolates

The wet mount technique employing lactophenol cotton blue for microscopic inspection of the fungal isolates and cultural and morphological parameters such colony development pattern, conidial morphology, and pigmentation for macroscopic examination were used to identify the fungal isolates [15].

Physico-Chemical Analysis

Physicochemical Examination we used the approach of [16] to determine the physicochemical characteristics. Using a straightforward thermometer that was calibrated in degrees Celsius, the temperature of the water sample was taken right away at the location of water collection. A veneer pH meter was used to monitor the pH. The method outlined by [16] was used to calculate the pH. A digital conductivity meter, NATOP PB5 (London, UK), was used to measure electrical conductivity. Standardization of the meter was carried out at 25°C with 0.1N KCl. Utilizing a digital turbidity meter (2100AN HARCH Model), the turbidity was measured. Clean deionized water was used to standardize the meter and was added to the water samples. Each sample's turbidity reading was then noted.

Using a conductivity meter, the total dissolved solid was ascertained by measuring 100 cm3 of the sample into a beaker, switching the conductivity meter's programming menu to total dissolved solid, and adding the electrode to the sample. The total dissolved solid findings were recorded and shown. A conical flask containing 10 cm3 of water was pipetted in order to measure the overall hardness. Three drops of Erichrome black T indicator and one centimeter of buffer solution (NH_4Cl) with a pH of 10 were added to the flask. Subsequently, the combination underwent a titration process using 0.01M ethyl diamine tetra acetic acid (EDTA) until the wine red color turned blue. To determine the average liter value, the process was carried out twice more. The determination of total alkalinity was done by measuring 100cm3 of water into a beaker where 2 –3 drops of phenolphthalein indicator was added. Colour change was observed.

RESULTS

The table 1 shows the microbial load of the various samples. The various samples were represented

with alphabets A, B, C, D, E, F, G, and H. The total heterotrophic bacteria count ranged from 6.0×10^3 to 3.0×10^4, the total coliform count ranged from 3.2×10^3 to 8.0×10^4 no growth was recorded for staphylococcal count and Total Fungal Count for the samples ranged from 3.0×10^3 to 6.0×10^4

Table 1: Microbial Loads of Samples

SAMPLES	THPC (Cfu/g)	TCC (Cfu/g)	TSC(Cfu/g)	TFC(Cfu/g)
A	9.4×10^3	5.4×10^4	No Growth	No Growth
B	6.0×10^4	6.0×10^4	No Growth	No Growth
C	4.2×10^3	3.2×10^3	No Growth	6.0×10^4
D	1.4×10^3	8.0×10^4	No Growth	4.2×10^3
E	6.0×10^4	6.0×10^4	No Growth	3.0×10^3
F	5.0×10^4	3.2×10^4	No Growth	5.0×10^4
G	7.0×10^3	4.9×10^4	No Growth	4.0×10^3

THPC= Total Heterotrophic Plate Count; TCC= Total Coliform Count; TSC = Total Staphylococcal Count;TFC= Total Fungal Count; A-D= Tap water; E-G= Spring water

Table 2 shows the morphological and colonial characteristics of bacteria isolates from the water samples and the characteristics shows that they are peculiar to Klebsiella spp, Bacillus spp, *E. coli* and Pseudomonas spp.

Table 2: Colonial and Morphological Characteristics of Bacterial Isolates

Sample	Colour	Shape	Surface	Arrangement	Probable organism
1	Creamy	Flat	Opaque	Rods	Bacillus spp
2	Pink	Raised growth	Smooth, Opaque and dry	Rods in singles	*Eschericia coli*
3	Pink	Raised growth	Slimy	Short Rods	Klebsiella spp
4	Greenish	Irregular	Smooth	Rods	Pseudomonas spp

Table 3 shows the biochemical properties of the isolated bacteria from water samples and their reactions to the various test the biochemical results shows that the bacteria isolated were Klebsiella spp, Bacillus spp, *E.coli* and Pseudomonas spp.

Table 3: Biochemical Properties of Bacterial Isolates

Isolates	Bacteriological tests			Biochemical tests										Probable organism
	Gram reaction test	Cellular arrangement	Motility test	Catalase test	Citrate test	Indole test	Oxidase test	Coagulase test	Voges Proskuer test	Methyl red test	Glucose test	Lactose test	Sucrose test	
1	-	Rods	+	+	+	-	+	-	-	-	-	-	-	Pseudomonas spp.
2	-	Rod	+	+	-	+	-	-	-	+	**A**	**A**	**A**	*Escherichia coli*
3	+	Rods	+	+	+	-	+	-	+	-	**A**	**-**	**A**	Bacillus spp
4	-	Rod	+	+	+	-	-	-	+	-	**A/G**	**A/G**	**A/G**	Klebsiella spp.

KEY: - = Negative; **+** = Positive; **A** = Acid; **A/G** = Acid and Gas production

Table 4 shows the percentage occurrences or distribution of the various bacteria isolates and the result reveals that Bacillus spp had a percentage distribution of 19, while Klebsiella spp had a percentage occurrence of 24, also Pseudomonas spp had a percentage distribution of 24 and *E. coli* had a percentage distribution of 33.

Table 4: Frequency Of Occurrence of Bacterial Isolates

ISOLATES	FREQUENCY	PERCENTAGE (%)
Bacillus spp	4	19
Pseudomonas spp	5	24
Eschericia coli	7	33
Klebsiella spp	5	24

ISOLATES	FREQUENCY	PERCENTAGE (%)
Total	21	100

Table 5 shows the macroscopic and microscopic characteristics of fungal isolates from the water samples and the characteristics shows that they are peculiar to *Penicillium* spp and *Aspergillus* spp.

Table 5: Colonial And Microscopic Morphology of Isolated Fungi Species

Colonial morphology	Microscopic morphology	Probable organism
Initially white colored fungi which later turned greenish, white mycelia at the margin and pale-yellow reverse color	Conidiospores bearing conidia with brush like spores	*Penicillium* spp.
Black sporing mat,with yellow terminals, un-elevated, milkfish reverse view	The vesicle of the conidiospores is large and globase, bearing two series of sterigmata over its entire surface. The conidia are brown to black and rough walled.	*Aspergillus niger.*

Table 6 shows the percentage occurrences or distribution of the various fungi isolates and the result reveals that Penicillium spp had a percentage distribution of 58, while Aspergillus spp had a percentage occurrence of 42.

Table 6: Frequency of Occurrence of Fungal Isolates

ISOLATES	FREQUENCY	PERCENTAGE (%)
Penicillium spp	7	58
Aspergillus spp	5	42
Total	12	100

Table 7: Physico-chemical Analysis of Tap Water

PARAMETERS	Tap water	Tap Water	Tap Water	Tap water
Temperature(^{0}C)	11	12	9.0	8
pH (Meter)	6.5	7.2	7.5	6.9
Turbidity (NTU)	0.4	1.0	2.2	2.7
Total Alkalinity (Mg/l)	82.0	86.6	96	91
Total hardness (Mg/l)	70	72	75	90
Total dissolved solid (Mg/l)	129	130	193	200
BOD (Mg/l)	0.2	0.19	0.28	0.3
Chloride (Mg/l)	44	55	76	80
Nitrite (Mg/l)	0.7	0.8	0.89	1.2
Nitrate (Mg/l)	33	38	39	50
Sulfate (Mg/l)	50	70	72	98

Table 8 Physico-Chemical Analysis of Spring Waters

Parameters	Spring Water	Spring Water	Spring Water
Temperature (^{0}C)	11	10	13
Turbidity (NTU)	0.3	1.6	2.0
pH (meter).	7.2	7.9	8.0
BOD (Mg/l)	0.1	0.2	0.32
Total alkalinity (Mg/l)	86	150	190
Total hardness (Mg/l)	85	120	200
Total dissolved solid (Mg/l)	77	250	300
Sulphate (Mg/l)	22	69	90
Chloride (Mg/l)	30	190	170
Nitrate (Mg/l)	23	30	35
Nitrite (Mg/l)	0.01	4	5

DISCUSSION

Following analysis of the water samples, the total count of heterotrophic bacteria ranged from 6.0×103 to 3.0×104, whereas the total count of coliforms ranged from 3.2×103 to 8.0×104. Staphylococcal count and total fungal count ranged from 3.0×103 to 6.0×104 for the samples, with no increase seen. The process of isolating and characterizing the isolates revealed that they were Pseudomonas, E. Coli, Bacillus, and

Klebsiella species. The percentage distribution of Bacillus spp. was 19, the percentage distribution of Klebsiella spp. was 24, the percentage distribution of Pseudomonas spp. was 24, and the percentage distribution of E. coli was 33.

Even though the bacteriological parameters were lower than those reported by [17] in sampling wells of the Idi Ayunre community, Oyo State, the bacteriological results for total coliform counts did not meet international standards since they were higher than the WHO standard of zero per 100ml. Additionally, the coliform levels in the studied wells in the Benue State towns of Makurdi and Samaru, Zaria, and Kaduna metropolis were higher. [18] A small number of public health pathogens, including E. Coli, Pseudomonas, Bacillus, and Klebsiella species, were isolated from tap and spring water sources for this investigation. This aligns with the research conducted by [19] in the Eyaen community Area of Edo State, Nigeria, where diseases including Vibrio cholera, Shigella, and Salmonella were isolated. Perhaps Pseudomas spp. are widely dispersed in soil. Hence, was isolated from all.

The following were the physicochemical features: The temperature of the tap water that was sampled was within the range provided by [20]. The prevailing consensus is that drinking water with a pH of 6.5 to 8.5 is adequate [4]. Acidic water can occasionally cause corrosion in plumbing and faucets, particularly when the pH drops below 6. This may therefore be the case, considering that the river water's pH analysis came up below 6. With the possible exception of the river sample's dissolved oxygen, which might be dangerous for consumers, all of the physicochemical characteristics of the water samples in this investigation were within the WHO norm. The pH range mentioned [20] was reached by the well fluids sampled in Kaduna City from several sources.

Turbidity levels were thought to be sufficient because they were below the WHO's threshold. The water sources' turbidity levels imply that there aren't many bacteria, planktons, or other suspended particles, nor are there many dissolved organic and inorganic compounds [21]. According to the level of the calculated values of total suspended solids (TSS), all water samples demonstrate the presence of minimal pollutants. Every measurement fell between the WHO's acceptable bounds. Likewise, the WHO recommendation value of 500 mg/l was met by the total dissolved solids in the water samples. Increased total dissolved solids have been shown to lower water clarity, which may result in less photosynthetic activity and may raise water temperature [22], which is not the case in this study. Since the turbidity readings were below the WHO's threshold, it was considered that they were sufficient. The water sources appear to have low quantities of bacteria, planktons, suspended materials, and dissolved organic and inorganic materials based on their turbidity levels [20]. The increased turbidity in river water, but not above the acceptable limit, is in line with prior reports linking turbidity to surface water sources. Total suspended solids (TSS) levels obtained for each water sample demonstrate the presence of few pollutants. Every measurement was within the WHO-permissible range. In a similar vein, water sample total dissolved solid readings fell between the 500 mg/l WHO recommended limits. Elevated total dissolved solids are reported to reduce water clarity, which could contribute to reduced photosynthetic activities and possibly lead to an increase in water temperature [24], which is not the case in this study.

CONCLUSION

This study found that while some of the water samples examined did not show any bacteria at all, others had loads of bacteria. The bacteria that were isolated are important for public health because they have been linked to disease outbreaks and, if consumed continuously, can pose serious health risks to humans by causing organisms to reach their threshold frequency and cause illness. In addition, the study area's water sources are safer to drink than those in other parts of Nigeria. Nevertheless, because the bacteriological readings from the total coliform count exceeded the WHO guideline of zero per 100 milliliter, they did not meet the international standard.

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